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JC10 Rec'd PCT/PTO 20 DEC 2001

BAKER BOTTS LLP TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35.U.S.C. 371	EXPRESS MAIL LABEL No. EF378764843US	DATE 12/20/01
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	U.S. APPLICATION NO. t/b/a 10/030340	

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/DE00/02117	June 29, 2000	July 7, 1999

TITLE OF INVENTION METHOD AND DEVICE FOR PRODUCING A STRAND MADE FROM METAL

APPLICANT(S) FOR DO/EO/US Andreas Kemna, Albrecht Sieber, Uwe Stuermer and Hans-Herbert Welker

Applicant herewith submits to the United States Designated /Elected Office (DO/EO/US) the following items and other information:

1. [x] This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. [x] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. [x] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [x] has been transmitted by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [x] A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. [ ] A copy of the International Search Report (PCT/ISA/210)
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.
8. [x] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. [x] A copy of the International Preliminary Examination Report (PCT/IPEA/409)
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [x] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.
14. [x] A substitute specification.
15. [ ] A change of power of attorney and/or address letter.
16. [ ] Other items or information:
    a. [x] a copy of the International Search Report (PCT/ISA/210)
    b. [x] a copy of the International Preliminary Examination Report (PCT/IPEA/409)

Comparison document; English and German versions of application; cover page of PCT international application PCT/DE00/02117; formal drawings (Figs. 1-2); postcard; and check in the amount of $740.00.

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INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
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				CALCULATIONS	PTO USE ONLY
17. [ ] The following fees are submitted: **Basic National Fee (37 CFR 1.492(a)(1)-(5):** Neither international preliminary examination fee (37 CFR 1.482) Nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO (1.492(a)(3)) $1,040 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO (1.492(a)(5) $890.00 International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO(1.492(a)(2)) $740.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) (1.492(a)(1)) $710.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $ 100.00					
ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 740	
Surcharge of $130.00 for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 C.F.R. 1.492)(e)).				$	
Claims	**Number Filed**	**Number Extra**	**Rate**	$	
Total Claims	9 -20=	0	X $ 18.00	$ 0	
Independent Claims	2 -3=	0	X $ 84.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $280.00	$	
TOTAL OF ABOVE CALCULATIONS =				$ 740	
Reduction by ½ for filing by small entity, if applicable.				$	
SUBTOTAL =				$ 740	
Processing fee of $130.00 for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 740	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 740	
				Amt. refunded	$
				charged	$

a. ✔ A check in the amount of $ 740.00 to cover the above fees is enclosed.

b. [ ] Please charge our Deposit Account No. 02-4377 in amount of $________ to cover the above fees. A copy of this sheet is enclosed.

c. ✔ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-4377. A copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:
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Attorney: Louis S. Sorell PTO Reg: 32,439

12/20/01

Date

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s)	:	Kemna et al.
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	METHOD AND DEVICE FOR PRODUCING A STRAND MADE FROM METAL
Examiner	:	To Be Assigned
Group Art Unit	:	To Be Assigned

Assistant Commissioner for Patents
Washington, DC 20231

PRELIMINARY AMENDMENT

Sir:

Kindly amend the above-identified application before examination as follows:

IN THE SPECIFICATION:

Please substitute the originally-filed specification with the Substitute Specification which is enclosed herewith. A comparison document showing the differences between the translation of the originally-filed specification and the enclosed Substitute Specification is also enclosed herewith.

IN THE CLAIMS:

Please cancel original claims 1-10 in the underlying PCT application, without prejudice.

Please add new claims 11-19, as follows:

11. A method for producing a metal strand using a continuous-casting installation which has at least one cooling device for cooling the strand, the cooling device being assigned at least one reduction stand for reducing the thickness of the strand, the strand, which during the thickness reduction has a solidified skin and a liquid core, said method comprising setting the cooling by means of a temperature and solidification model so that a solidification boundary between the solidified skin and the liquid core when the strand enters the reduction stand corresponds to a predetermined set solidification boundary between the solidified skin and the liquid core.

12. The method according to claim 11, further comprising using the temperature and solidification model to determine the solidification boundary between the solidified skin and the liquid core as a function of the cooling of the strand, and determining the required cooling of the strand iteratively as a function of the predetermined set solidification boundary, iteration being repeated until any deviation in the solidification boundary from the predetermined set solidification boundary is less than a predetermined tolerance value.

13. The method according to claim 11, further comprising using at least one variable selected from the group of variables consisting of strand velocity, strand

geometry, strand shell thickness, mold length, time, strand material, coolant pressure or volume, droplet size of the coolant and coolant temperature to determine the cooling of the strand as a function of the predetermined set solidification boundary.

14. The method according to claim 13, further comprising using the variables strand geometry, strand shell thickness, time, strand material, coolant pressure and volume, and coolant temperature to determine the cooling of the strand as a function of the solidification boundary.

15. The method according to claim 11, further comprising arranging at least two reduction stands downstream of the cooling device, and wherein the said at least two reduction stands are assigned a set solidification boundary between the solidified skin and the liquid core of the strand when it enters a reduction stand.

16. The method according to claim 11, further comprising taking into account the position of the solidification boundary between solidified skin and liquid core in the temperature and solidification model.

17. The method according to claim 13, wherein modeling of the reduction in thickness produced by the reduction stand is carried out using at least one of the variables reduction force and degree of reduction in thickness.

18. The method according to claim 13, wherein at least one of the variables reduction force and degree of reduction is measured in the reduction stand and is used to adapt the temperature and solidification model.

19. A continuous-casting installation for producing a metal strand, comprising at least one cooling device for cooling the strand and at least one associated reduction stand for reducing the thickness of the strand, and a computing device for controlling the cooling of the strand by means of the cooling device, wherein a temperature and solidification model for setting a solidification boundary between a solidified skin and a liquid core of the strand when the strand enters the reduction stand is implemented in the computing device, and the solidification boundary corresponds to a predetermined set solidification boundary between the solidified skin and the liquid core.—

A "Version With Marked Changes Made" is submitted herewith.

REMARKS

This Preliminary Amendment cancels, without prejudice, originally-filed claims 1-10 in underlying PCT Application No. PCT/DE00/02117. New claims 11-19 have been added merely to conform the claims to U.S. Patent and Trademark Office practice and standards, and do not add new matter to the application. Furthermore, the addition of these new claims in no way addresses any issues of patentability, and the new claims are provided to place the application in condition for allowance.

The amendment to the substitute specification is provided to correct grammatical and syntactical errors and otherwise to conform the specification and abstract of the above-identified application to the U.S. Patent and Trademark Office practice. No new matter has been introduced to the application.

The amendments to the "Claims" are reflected in the attached "Version With Marked Changes Made."

Favorable consideration on the merits is respectfully requested.

Respectfully submitted,

Dated: December 20, 2001

By:______________________________

Louis S. Sorell
Reg. No. 32,439

BAKER BOTTS L.L.P.
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Version With Marked Changes Made

We Claim:

11. ~~1.~~ A method for producing a ~~strand (1) made from~~ metal ~~by means of~~strand using a continuous-casting installation which has at least one cooling device ~~(5)~~ for cooling the strand ~~(1)~~, the cooling device ~~(5)~~ being assigned at least one reduction stand ~~(9, 10, 11)~~ for reducing the thickness of the strand ~~(1)~~, the strand ~~(1)~~, which during the thickness reduction~~,~~ ~~having~~has a solidified skin ~~(21)~~ and a liquid core ~~(2)~~, ~~characterized in that~~said method comprising setting the cooling ~~is set,~~ by means of a temperature and solidification model ~~(13), in such a manner~~so that ~~the~~a solidification boundary ~~(22)~~ between the solidified skin ~~(21)~~ and the liquid core ~~(2)~~ when the strand ~~(1)~~ enters the reduction stand ~~(9, 10, 11)~~ corresponds to a predetermined set solidification boundary between the solidified skin ~~(21)~~ and the liquid core ~~(2)~~.

~~2.~~ The method ~~as claimed in claim 1, characterized in that~~according to claim 11, further comprising using the temperature and solidification model ~~(13) is used~~ to determine the solidification boundary ~~(22)~~ between the solidified skin ~~(21)~~ and the liquid core ~~(2)~~ as a function of the cooling of the strand ~~(1)~~, ~~in particular in real time~~ and ~~continuously, and in that~~determining the required cooling of the strand ~~(1) is determined~~ iteratively as a function of the predetermined set solidification boundary ~~(e_0) between the solidified skin (21) and the liquid core (2)~~, iteration being repeated until ~~the~~any deviation in the solidification boundary ~~(e_i) between the solidified skin (21) and the liquid core (2), which has been determined using the temperature and solidification model (13),~~ from the predetermined set solidification boundary ~~(e_i) between the solidified skin (21) and the liquid core (2)~~

~~is less than a predetermined tolerance value.~~ is less than a predetermined tolerance value.

12. ~~3.~~ The method ~~as claimed in claim 1 or 2, characterized in that~~according to claim 11, further comprising using at least one ~~further~~ variable selected from the group of variables consisting of strand velocity, strand geometry, strand shell thickness, ~~mould~~mold length, time, strand material, coolant pressure or volume, droplet size of the coolant and coolant temperature ~~is used~~ to determine the ~~required~~ cooling of the strand ~~(1)~~ as a function of the predetermined set solidification boundary ~~between the solidified skin (21) and the liquid core (2)~~.

13. ~~4.~~ The method ~~as claimed in claim 1, 2 or 3, characterized in that~~according to claim 13, further comprising using the variables strand geometry, strand shell thickness, time, strand material, coolant pressure and volume, and coolant temperature ~~are also used~~ to determine the ~~required~~ cooling of the strand ~~(1)~~ as a function of the solidification boundary ~~(22) between the solidified skin (21) and the liquid core (2)~~.

14. ~~5.~~ The method ~~as claimed in claim 1, 2, 3 or 4 in which~~according to claim 11, further comprising arranging at least two reduction stands ~~(9, 10, 11) are arranged~~ downstream of the cooling device ~~(5)~~, ~~characterized in that~~and wherein the said at least two reduction stands ~~(9, 10, 11)~~ are assigned a set solidification boundary between the solidified skin ~~(21)~~ and the liquid core ~~(2)~~ of the strand ~~(1)~~ when it enters ~~the~~a reduction stand ~~(9, 10, 11) in question~~.

15. ~~6.~~ The method ~~as claimed in claim 1, 2, 3, 4 or 5, characterized in that the action of the reduction in thickness produced by the reduction stand (9, 10, 11), in particular~~according to claim 11, further comprising taking into account the position of the solidification boundary ~~(22)~~ between solidified skin ~~(21)~~ and liquid core ~~(2), is also taken into account~~ in the temperature and solidification model ~~(13)~~.

16. ~~7.~~ The method ~~as claimed in~~according to claim ~~5, characterized in that the~~ 13, wherein modeling of the reduction in thickness produced by the reduction stand ~~(9, 10, 11)~~ is carried out using at least one of the variables reduction force and degree of reduction in thickness.

17. ~~8. The method as claimed in one of the preceding claims, characterized in that at least one of the variables reduction force and degree of reduction is measured in the reduction stand (9, 10, 11) and is used to adapt the temperature and solidification model (13).~~

18. ~~9. The method as claimed in claim 8, characterized in that~~The method according to claim 13, wherein at least one of the variables reduction force and degree of reduction is measured in the reduction stand ~~(9, 10, 11) are measured~~ and ~~are~~is used to adapt the temperature and solidification model ~~(13)~~.

19. ~~10.~~ A continuous-casting installation for producing a metal strand ~~(1)~~, ~~in particular using the method as claimed in one of the preceding claims, the continuous-casting installation having~~comprising at least one cooling device ~~(5)~~ for cooling the strand ~~(1)~~ and at least one associated reduction stand ~~(9, 10, 11)~~ for reducing the

thickness of the strand ~~(1)~~, and a computing device for controlling the cooling of the strand by means of the cooling device ~~(5)~~, ~~characterized in that~~wherein a temperature and solidification model ~~(13) for such a~~ setting ~~of the~~a solidification boundary ~~(22)~~ between a solidified skin ~~(21)~~ and a liquid core ~~(2)~~ of the strand ~~(1)~~ when the strand ~~(1)~~ enters the reduction stand ~~(9, 10, 11)~~ is implemented ~~on~~in the computing device, and ~~in that~~ the solidification boundary ~~(22)~~ corresponds to a predetermined set solidification boundary between the solidified ~~skin (21) and the liquid core (2).~~skin and the liquid core.

BAKER BOTTS L.L.P.

30 ROCKEFELLER PLAZA

NEW YORK, NEW YORK 10112

TO ALL WHOM IT MAY CONCERN:

Be it known that WE, Andreas Kemna, Albrecht Sieber, Uwe Stuermer and Hans-Herbert Welker, citizens of Germany, whose post office addresses are Waldstr. 7, 91052 Erlangen, Germany; Kornweg 4, 91096 Moehrendorf, Germany; Ludwig-Thoma-Str. 17, 91083 Baiersdorf, Germany; and Langenzenner Str. 9, 91074 Herzogenaurach, Germany; respectively, have invented an improvement in:

METHOD AND DEVICE FOR PRODUCING A STRAND MADE FROM METAL

of which the following is a

SUBSTITUTE SPECIFICATION

FIELD OF INVENTION

[0001] The invention relates to a method and a device for producing a strand of metal by means of a continuous-casting installation which has at least one cooling device for cooling the strand, the cooling device being assigned at least one reduction stand for reducing the thickness of the strand, which during the thickness reduction has a solidified skin and a liquid core.

[0002] In the production of strands of metal it is known for a reduction stand to be assigned (downstream) to a continuous-casting installation. A particularly substantial reduction in thickness is achieved if the strand has a core which is still liquid when it enters the reduction stand. In this method, which is known as soft reduction, it is important for the liquid core to be large enough to ensure the required reduction in thickness of the strand while also not being so large that the strand breaks open and the liquid metal escapes. To achieve the required size of the liquid core on reaching the reduction stand, the strand is cooled by means of a cooling device, the cooling required being set by an operator after he has estimated the size of the liquid core. The document "Neubau einer Vertikalstranggießanlage bei der AG der Dillinger Hüttenwerke"; [Construction of a new vertical continuous-casting installation at Dillinger Hüttenwerke AG]" Stahl and Eisen 117, No. 11; 10 November 1997, demonstrates the problems of the location and positioning of the blunt tip of a strand in relation to the soft reduction zone, and it is taught that the soft reduction zone should be tracked beyond the respective position of the blunt tip during casting. This is possible through the fact that the segments can be hydraulically positioned in the strand-guiding section.

SUMMARY OF INVENTION

[0003] It is an object of the present invention to provide a method and a device for carrying out the method which allows soft reduction which is an improvement over the prior art, particularly when the strand velocity varies. This object is achieved by

producing a strand made from metal by means of a continuous-casting installation which has at least one cooling device for cooling the strand, at least one reduction stand for reducing the thickness of the strand arranged downstream of the cooling device. During the reduction in thickness, the strand has a solidified skin and a liquid core, and the cooling is set, by means of a temperature and solidification model, in particular automatically, in such a manner that the solidification boundary between the solidified skin and the liquid core when the strand enters the reduction stand corresponds to a predetermined set solidification boundary between the solidified skin and the liquid core. In this way, particularly good soft reduction is achieved. Reduction stands used in the context of the present invention, may, in addition to simple rolling stands, be complex rolling stands, which impart a defined geometry to the strand by rolling. The temperature and solidification model, for example, may be an analytical model, a neural network, or a combination of an analytical model and a neural network. The temperature and solidification model relates the cooling of the strand to the solidification boundary between the solidified skin and the liquid core. Such a configuration of the invention is particularly advantageous since the temperature and solidification model simulates the solidification boundary between the solidified skin and the liquid core as a function of the amount of cooling, using the cause-effect relationship between cooling and the solidification boundary between the solidified skin and the liquid core.

[0004] In a preferred embodiment of the present invention, the temperature and solidification model is used to determine the solidification boundary between the

solidified skin and the liquid core as a function of the cooling of the strand, in particular in real time and continuously. The required cooling of the strand is determined iteratively as a function of the predetermined set solidification boundary between the solidified skin and the liquid core. Iteration is repeated until the deviation in the solidification boundary between the solidified skin and the liquid core (which has been determined using the temperature and solidification model), from the predetermined set solidification boundary between the solidified skin and the liquid core is less than a predetermined tolerance value.

[0005] In another preferred embodiment of the present invention, at least one further variable, selected from the group consisting of strand velocity, strand geometry, strand shell thickness, mold length, time, strand material, coolant pressure or volume, droplet size of the coolant, and coolant temperature is used to determine the required cooling of the strand as a function of the predetermined set solidification boundary between the solidified skin and the liquid core.

[0006] In a further preferred embodiment of the present invention, the strand geometry, strand shell thickness, time, strand material, coolant pressure or volume and coolant temperature variables are also used to determine the required cooling of the strand as a function of the solidification boundary between the solidified skin and the liquid core. The use of these variables is particularly suitable for achieving a precise cooling of the strand.

[0007] In yet another preferred embodiment, each reduction device is assigned a set solidification boundary between the solidified skin and the liquid core of the strand.

[0008] In another preferred embodiment of the invention, the action of the reduction in thickness produced by the reduction stand, in particular the position of the solidification boundary between solidified skin and liquid core, is also modeled in the temperature and solidification model.

[0009] In a further preferred embodiment of the invention, the modeling of the reduction in thickness produced by the reduction stand is carried out using at least one of the variables reduction force and degree of reduction.

[0010] In a further preferred embodiment of the invention, at least one of the variables reduction force and degree of reduction is measured in the reduction stand and, is used to adapt the temperature and solidification model.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Further advantages and details of the present invention are described below with reference to the drawings in which:

FIGURE 1 illustrates a continuous-casting installation;

FIGURE 2 illustrates a flow diagram for the iterative determination of desired cooling of the strand by means of a temperature and solidification model; and

FIGURE 3 illustrates a flow diagram for the iterative determination of an

adaptation coefficient.

DETAILED DESCRIPTION OF THE INVENTION

[0012] FIGURE 1 shows a continuous-casting installation. Reference numeral 1 denotes the cast strand, which has a solidified skin 21 inside a solidification boundary 22 and a liquid core 2. The strand is moved using drive and guide rolls 4 and is cooled as it passes through cooling devices 5, which are preferably designed as water-spraying devices. For the sake of simplicity, not all the drive and guide rolls 4 and cooling devices 5 are provided with reference numerals. In known methods, the cooling devices 5 are divided into cooling segments. This division is not necessary in the method of the present invention, but can nevertheless be included. Both the drive rolls 4 and the cooling devices 5 are connected in terms of data technology to a computing device. In the present exemplary embodiment, bugs are connected in terms of data technology to the same automation unit 7. The automation unit 7 optionally also has a terminal (not shown) and a keyboard (not shown). In addition, the automation unit 7 is connected to a higher-level computer system 8. The material required for continuous casting, in this case liquid steel, is supplied via a feed apparatus 20. The control variables for the cooling devices 5 are calculated by means of a temperature and solidification model, i.e. a thermal model of the strand which is implemented on the higher-level computer system 8.

[0013] Reference numerals 9, 10 and 11 denote reduction stands assigned to the cooling device 5. In a preferred embodiment of the invention these stands are

connected in terms of data technology to the programmable-memory control unit 7. The rolling force and the degree of reduction, for example in the form of the roll nip, is transmitted to the automation unit 7. FIGURE 1 illustrates three reduction stands 9, 10 and 11. In the exemplary embodiment, only a soft reduction is carried out in the reduction stands 9 and 10. In soft reduction, the strand which is to be reduced is not fully solidified, but rather has a liquid core 2 and a solidified skin 21 when it enters a reduction stand. As shown in FIGURE 1, only soft reduction for the strand 1 is provided in the reduction stands 9 and 10. Using the devices 5 the cooling is set by means of the automation unit 7 in such a manner that the solidification boundary 22 between the solidified skin 21 and the liquid core 2 of the strand 1 when it enters the reduction stands 9 and 10 corresponds to a desired set solidification boundary between the liquid core 2 and the solidified skin 21.

[0014] It is preferred for the reduction stand 9 to be arranged inside the cooling section, i.e. cooling devices 5 are provided upstream and downstream of the reduction stand 9. Furthermore, it is preferable for the cooling devices to be provided downstream of the second reduction stand 10. The cooling device 9 is preferably not arranged over the bending of the strand 1, as indicated in FIGURE 1, but rather is arranged upstream of the bending of the strand or downstream of the bending of the strand 1.

[0015] FIGURE 2 illustrates a flow diagram for the iterative determination of a set value k_0 for the cooling of the strand by means of a temperature and solidification

[redacted]

model 13. The temperature and solidification model 13 and the remaining iterative sequences illustrated are implemented on the higher-level computer system 8. In the temperature and solidification model 13 the solidification boundaries e_i in the strand are determined from the given cooling of the strand k_i by means of the temperature and solidification model 13. In a comparison unit 14, this solidification boundary e_i is compared with the set solidification boundary e_o in the strand. The comparison unit 14 interrogates whether $|e_i-e_o| \leq \Delta e_{max}$, where Δe_{max} is a predetermined tolerance value. If the difference between e_i and e_o is too high, the function block 12 determines a new proposal k_i for improved cooling of the strand. A value for the cooling which has proven to be a suitable empirical value on average over a prolonged period is used as the starting value for the iteration. If the difference between e_i and e_o is less than or equal to the tolerance value Δe_{max}, a set cooling fixing 15 is used to set the value k_o for the cooling of the strand so as to be equal to the value k_i. The values e_i, e_o, Δe_{max}, k_i, k_o are not necessarily scalars, but rather column matrices with one or more values. For example, the column matrix k_o contains the various control and command variables for the cooling devices 5 of the individual cooling segments 6 of a strand-cooling installation, or the column matrix e_o contains the set solidification boundaries at various locations of the strand. In a preferred embodiment, the iteration cycle illustrated in FIGURE 2 takes place on the basis of genetic algorithms. This is particularly recommended if k_i and k_o are column matrices containing numerous elements.

[0016] The temperature and solidification model 13 can be implemented both as a one-dimensional model and as a two-dimensional model. The heat conduction equation:

$$\frac{\partial T}{\partial t} = a\left(\frac{\partial^2 T}{\partial^2} + \frac{\partial^2 T}{\partial y^2}\right) \qquad (1)$$

which for the temperature and solidification model 13 is used in difference form, i.e. in the form

$$\Delta_t T - a\Delta T\left(\frac{1}{\Delta x^2}\Delta_x^2 T + \frac{1}{\Delta y^2}\Delta_y^2 T\right) \qquad (2)$$

forms the basis for the temperature and solidification model, in this case shown as two-dimensional. In these equations, T is the temperature, t is the time and a is the thermal conductivity. The two-dimensional spatial coordinates are x and y.

[0017] The cross section of the strand skin is divided into small rectangles Δx by Δy, and the temperature is calculated in small time steps Δt. The starting point used for the temperature distribution is based on the assumption that the temperature on entry into the mould (in all rectangles) is the same as the tundish temperature of the steel.

[0018] The heat flux Q which is to be dissipated at the surface of the strand is calculated from the surface temperature T_o of the strand, the ambient temperature T_u, the surface area A and the heat transfer coefficient α, where $Q = \alpha\ (T_u - T_o)\ A$. For cooling in the mould, α is assumed to be constant and t_u is deemed to be equal to the

temperature of the cooling water in the mould. For cooling by the cooling devices 5, T_U is assumed to be the same as the temperature of the coolant and α is calculated, for example, as:

$$\alpha = \left(200 + 1.82V \frac{m^2 \min}{1}\right) \frac{w}{m^2 K} \tag{3}$$

where V is the coolant volume in $\frac{l}{m^2 \, min}$. V can be given differently for any point on the strand surface, with the result that the model can also be used to describe nozzle characteristics.

[0019] The model also calculates the profile of the solidification boundary from the profile of the temperature distribution in the strand.

[0020] The individual modeling parameters (variables) include:

- Mould length
- Strand geometry (height and width)
- Strand velocity
- Heat transfer coefficient α in the mould
- Coolant temperature in the mould
- Melt temperature
- Enthalpy of solidification
- Thermal conduction coefficient λ
- Specific heat capacity c
- Density ρ
- Length of each cooling zone
- Coolant volume V in each cooling zone
- Strand material

[0021] The temperature and material dependency of λ, c, enthalpy and ρ is taken into account in the model.

[0022] FIGURE 3 shows a flow diagram for the iterative determination of an adaptation coefficient d_o for adapting the heat transfer coefficient α by means of a temperature and solidification model 13, the adapted heat transfer coefficient α_a being determined from the heat transfer coefficient α by

$$\alpha_a = d_o * \alpha.$$

[0023] For this purpose, the solidification boundaries e_i in the strand are determined from given cooling of the strand by means of the temperature and solidification model 13. In a comparison unit 17, this solidification boundary e_i is compared with the roll strokes $\Delta W_{j,y,u}$ (lower) and $\Delta W_{j,y,o}$ (upper), which occur in the reduction stands and the rolling forces $F_{j,u}$ (lower) and $F_{j,o}$ (upper) in the reduction stands. If the values of the roll strokes which are typical for a change in geometry are undershot and/or the values of the rolling forces which are typical for a change in geometry are exceeded, the function block 16 determines a new proposal for an improved adaptation factor d_i. As a result, the solidification boundary is shifted until the corresponding limit values are exceeded or undershot, respectively. The starting value used for the iteration is a value $d_o = 1$. The end of the iteration is set by the function block 18 $d_o = d_i$. The heat transfer coefficient α in equation 3 is replaced by the adapted heat transfer coefficient α_a.

[0024] It is preferred if a pilot control is provided for the cooling device, in which case the transmission dependency of known times of the changes of installation values, such as the casting rate and/or the strand material, takes place.

ABSTRACT

A method and device for producing a strand of metal by means of a continuous-casting installation which has at least one cooling device for cooling the strand, the cooling device being assigned at least one reduction stand for reducing the thickness of the strand, the strand, during the thickness reduction, having a solidified skin and a liquid core. The cooling is set, by means of a temperature and solidification model, in such a manner that the solidification boundary between the solidified skin and the liquid core when the strand enters the reduction stand corresponds to a predetermined set solidification boundary between the solidified skin and the liquid core.

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TO ALL WHOM IT MAY CONCERN:

Be it known that WE, Andreas Kemna, Albrecht Sieber, Uwe Stuermer and Hans-Herbert Welker, citizens of Germany, whose post office addresses are Waldstr. 7, 91052 Erlangen, Germany; Kornweg 4, 91096 Moehrendorf, Germany; Ludwig-Thoma-Str. 17, 91083 Baiersdorf, Germany; and Langenzenner Str. 9, 91074 Herzogenaurach, Germany; respectively, have invented an improvement in:

METHOD AND DEVICE FOR PRODUCING A STRAND MADE FROM METAL

of which the following is a

SPECIFICATION

FIELD OF INVENTION

[0001] The invention relates to a method and a device for producing a strand of metal by means of a continuous-casting installation which has at least one cooling device for cooling the strand, the cooling device being assigned at least one reduction stand for reducing the thickness of the strand, ~~the strand,~~which during the thickness reduction~~,~~ ~~having~~has a solidified skin and a liquid core.

[0002] ~~To produce~~In the production of strands~~,~~ of metal it is known for a reduction stand to be assigned (downstream) to a continuous-casting installation. A particularly substantial reduction in thickness is achieved if the strand has a core which is still liquid when it enters the reduction stand. In this method, which is known as soft reduction, it is important for the liquid core to be large enough to ensure the required reduction in thickness of the strand while also not being so large that the strand breaks open and the liquid metal escapes. To achieve the required size of the liquid core on reaching the reduction stand, the strand is cooled by means of a cooling device, the cooling required being set by an operator after he has estimated the size of the liquid core. The document "Neubau einer Vertikalstranggießanlage bei der AG der Dillinger Hüttenwerke"; [Construction of a new vertical continuous-casting installation at Dillinger Hüttenwerke AG]" Stahl and Eisen 117, No. 11; 10 November 1997, demonstrates the problems of the location and positioning of the blunt tip of a strand in relation to the soft reduction zone, and it is taught that the soft reduction zone should be tracked beyond the respective position of the blunt tip during casting. This is possible through the fact that the segments can be hydraulically positioned in the strand-guiding section.

~~**[0003]** It is an object of the invention to provide a method and a device for carrying out the method which allows soft reduction which is improved compared to the prior art, in particular even when the strand velocity varies.~~

SUMMARY OF INVENTION

[0003] ~~[0004] According to the invention, the~~It is an object of the present~~It is an object of the~~ invention to provide a method and a device for carrying out the method which allows soft reduction which is ~~improved compared to the prior art, in particular even~~an improvement over the prior art, particularly when the strand velocity varies. This object is achieved by ~~a method as described in claim 1 and a device as described in claim 10. To produce~~producing a strand made from metal by means of a continuous-casting installation which has at least one cooling device for cooling the strand, at least one reduction stand for reducing the thickness of the strand ~~is~~ arranged downstream of the cooling device~~, the strand, during~~. During the reduction in thickness, ~~having~~the strand has a solidified skin and a liquid core, and the cooling ~~being~~is set, by means of a temperature and solidification model, in particular automatically, in such a manner that the solidification boundary between the solidified skin and the liquid core when the strand enters the reduction stand corresponds to a predetermined set solidification boundary between the solidified skin and the liquid core. In this way, particularly good soft reduction is achieved. Reduction stands used in the context of the present invention, may, in addition to simple rolling stands, be complex rolling stands, ~~by means of~~ which impart a defined geometry ~~is imparted~~ to the strand by rolling. The temperature and solidification model ~~may~~, for example, may be an analytical model, a neural network, or a combination of an analytical model and a neural network. The temperature and solidification ~~model advantageously~~model relates the cooling of the strand to the solidification boundary between the solidified skin and the liquid core. Such a configuration of the invention is particularly

advantageous~~,~~ since the temperature and solidification model simulates the solidification boundary between the solidified skin and the liquid core as a function of the amount of cooling, using the cause-effect relationship between cooling and the solidification boundary between the solidified skin and the liquid core.

~~**[0005]** The temperature and solidification **model advantageously** relates the cooling of the strand to the solidification boundary between the solidified skin and the liquid core. Such a configuration of the invention is particularly advantageous, since the temperature and solidification model simulates the solidification boundary between the solidified skin and the liquid core as a function of the amount of cooling using the cause-effect relationship between cooling and the solidification boundary between the solidified skin and the liquid core.~~

[0004] ~~**[0006]**~~ In ~~an advantageous configuration~~a preferred embodiment of the present invention, the temperature and solidification model is used to determine the solidification boundary between the solidified skin and the liquid core as a function of the cooling of the strand, in particular in real time and continuously~~, and the~~. The required cooling of the strand is determined iteratively as a function of the predetermined set solidification boundary between the solidified skin and the liquid core~~, iteration being~~. Iteration is repeated until the deviation in the solidification boundary between the solidified skin and the liquid core~~,~~ (which has been determined using the temperature and solidification model), from the predetermined set

solidification boundary between the solidified skin and the liquid core is less than a predetermined tolerance value.

[0005] ~~[0007]~~ In ~~a further advantageous configuration~~another preferred embodiment of the present invention, at least one further variable, selected from the ~~variables~~group consisting of strand velocity, strand geometry, strand shell thickness, ~~mould~~mold length, time, strand material, coolant pressure or volume, droplet size of the coolant, and coolant temperature is used to determine the required cooling of the strand as a function of the predetermined set solidification boundary between the solidified skin and the liquid core.

[0006] ~~[0008]~~ In a further ~~advantageous~~preferred ~~configuration~~embodiment of the present invention, the ~~variables~~ strand geometry, strand shell thickness, time, strand material, coolant pressure or volume and coolant temperature variables are also used to determine the required cooling of the strand as a function of the solidification boundary between the solidified skin and the liquid core. The use of these variables is particularly suitable for achieving a ~~particularly~~ precise cooling of the strand.

[0007] ~~[0009]~~ In ~~a further advantageous configuration of the invention~~yet another preferred embodiment, each reduction device is assigned a set solidification boundary between the solidified skin and the liquid core of the strand.

[0008] ~~[0010]~~ In ~~a further advantageous configuration~~another preferred embodiment of the invention, the action of the reduction in thickness produced by the reduction

stand, in particular the position of the solidification boundary between solidified skin and liquid core, is also modeled in the temperature and solidification model.

[0009] ~~[0011]~~ In a further ~~advantageous~~preferred ~~configuration~~embodiment of the invention, the modeling of the reduction in thickness produced by the reduction stand is carried out using at least one of the variables reduction force and degree of reduction.

[0010] ~~[0012]~~ In a further ~~advantageous~~preferred ~~configuration~~embodiment of the invention, at least one of the variables reduction force and degree of reduction is measured in the reduction stand and, is used to adapt the temperature and solidification model.

~~[0013] In a further advantageous configuration of the invention, the variables reduction force and degree of reduction are measured in the reduction stand and are used to adapt the temperature and solidification model.~~

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] ~~[0014]~~ Further advantages and ~~inventive~~ details ~~will emerge from the following description of an exemplary embodiment,~~of the present invention are described below with reference to the drawings ~~and~~ in ~~conjunction with the subclaims. In the drawing~~which:

~~FIG. 1 shows a continuous casting installation,~~

~~FIG. 2~~ ~~shows a flow diagram for the iterative determination of desired cooling of the strand by means of a temperature and solidification model,~~

~~FIG. 3~~ ~~shows a flow diagram for the iterative determination of an adaptation coefficient.~~

FIGURE 1 illustrates a continuous-casting installation;

FIGURE 2 illustrates a flow diagram for the iterative determination of desired cooling of the strand by means of a temperature and solidification model; and

FIGURE 3 illustrates a flow diagram for the iterative determination of an adaptation coefficient.

DETAILED DESCRIPTION OF THE INVENTION

[0012] ~~[0015]~~ ~~FIG.~~FIGURE 1 shows a continuous-casting installation. Reference numeral 1 denotes the cast strand, which has a solidified skin 21 inside a solidification boundary 22 and a liquid core 2. The strand is moved using drive and guide rolls 4 and is cooled as it passes through cooling devices 5, which are ~~advantageously~~preferably designed as water-spraying devices. For the sake of ~~clarity~~simplicity, not all the drive and guide rolls 4 and cooling devices 5 are provided with reference numerals. In known methods, the cooling devices 5 are divided into cooling segments. This division is not necessary in the ~~novel and inventive~~ method of the present invention, but ~~may~~can ~~also~~nevertheless be included. Both the drive rolls 4

and the cooling devices 5 are connected in terms of data technology to a computing device. In the present exemplary embodiment, bugs are connected in terms of data technology to the same automation unit 7. The automation unit 7 optionally also has a terminal (not shown) and a keyboard (not shown). In addition, the automation unit 7 is connected to a higher-level computer system 8. The material required for continuous casting, in this case liquid steel, is supplied via a feed apparatus 20. The control variables for the cooling devices 5 are calculated by means of a temperature and solidification model, i.e. a thermal model of the strand~~,~~ which ~~in the exemplary configuration~~ is implemented on the higher-level computer system 8.

[0013] ~~**[0016]**~~ Reference numerals 9, 10 and 11 denote reduction stands assigned to the cooling device 5. ~~In an advantageous configuration~~ In a preferred embodiment of the invention~~,~~ these stands are connected in terms of data technology to the programmable-memory control unit ~~7, the~~7. The rolling force and the degree of reduction, for example in the form of the roll nip, ~~being~~is transmitted to the automation unit 7. ~~In the present exemplary embodiment,~~ FIGURE 1 illustrates three reduction stands 9, 10 and ~~11 are provided.~~ 11. In the exemplary embodiment ~~illustrated in FIG. 1,~~, only a ~~so-called~~ soft reduction is carried out in the reduction stands 9 and 10. In soft reduction, the strand which is to be reduced is not fully solidified, but rather has a liquid core 2 and a solidified skin 21 when it enters a reduction stand. ~~In the exemplary embodiment~~ As shown in ~~FIG.~~FIGURE 1, only soft reduction for the strand 1 is provided in the reduction stands 9 and 10. ~~The cooling~~

~~using~~ Using the ~~cooling~~ devices 5 the cooling is set by means of the automation unit 7 in such a manner that the solidification boundary 22 between the solidified skin 21 and the liquid core 2 of the strand 1 when it enters the reduction stands 9 and 10 corresponds to a desired set solidification boundary between the liquid core 2 and the solidified skin 21.

[0014] **~~[0017]~~** It is ~~particularly advantageous~~preferred for the reduction stand 9 to be arranged inside the cooling section, i.e. cooling devices 5 are provided upstream and downstream of the reduction stand 9. Furthermore, it is ~~advantageously also possible~~preferable for the cooling devices to be provided downstream of the second reduction stand 10. The cooling device 9 is ~~advantageously~~preferably not arranged over the bending of the strand 1, as indicated ~~for the sake of clarity~~ in ~~FIG.~~FIGURE 1, but rather is arranged upstream of the bending of the strand or downstream of the bending of the strand 1.

[0015] **~~[0018]~~** ~~FIG.~~FIGURE 2 ~~shows~~illustrates a flow diagram for the iterative determination of a set value k_0 for the cooling of the strand by means of a temperature and solidification model ~~13, the~~13. The temperature and solidification model 13 and the remaining iterative sequences illustrated ~~being~~are implemented on the higher-level computer system 8. ~~For this purpose, in~~ In the temperature and solidification model 13 the solidification boundaries e_i in the strand are determined from the given cooling of the strand k_i by means of the temperature and solidification model 13. In a comparison unit 14, this solidification boundary e_i is compared with the set

solidification boundary e_o in the strand. The comparison unit 14 interrogates whether $|e_i-e_o| \leq \Delta e_{max}$, where Δe_{max} is a predetermined tolerance value. If the difference between e_i and e_o is too high, the function block 12 determines a new proposal k_i for improved cooling of the strand. A value for the cooling which has proven to be a suitable empirical value on average over a prolonged period is used as the starting value for the iteration. If the difference between e_i and e_o is less than or equal to the tolerance value Δe_{max}, a set cooling fixing 15 is used to set the ~~set~~ value k_o for the cooling of the strand so as to be equal to the value k_i. The values e_i, e_o, Δe_{max}, k_i, k_o are not necessarily scalars, but rather column matrices with one or more values. For example, the column matrix k_o contains the various control and command variables for the cooling devices 5 of the individual cooling segments 6 of a strand-cooling installation, or the column matrix e_o contains the set solidification boundaries at various locations of the strand. In ~~an advantageous configuration~~a preferred embodiment, the iteration cycle illustrated in ~~FIG~~FIGURE 2 takes place on the basis of genetic algorithms. This is particularly recommended ~~in particular~~ if k_i and k_o are column matrices containing numerous elements.

[0016] ~~**[0019]**~~ The temperature and solidification model 13 can be implemented both as a one-dimensional model and as a two-dimensional model. The heat conduction equation:

$$\frac{\partial T}{\partial t} = a\left(\frac{\partial^2 T}{\partial^2} + \frac{\partial^2 T}{\partial y^2}\right) \qquad (1)$$

which for the temperature and solidification model 13 is used in difference form, i.e. in the form

$$\Delta_t T - a\Delta T\left(\frac{1}{\Delta x^2}\Delta_x^2 T + \frac{1}{\Delta y^2}\Delta_y^2 T\right) \tag{2}$$

forms the basis for the temperature and solidification model, in this case shown ~~for the~~as two-dimensional~~ case~~. In these equations, T is the temperature, t is the time and a is the thermal conductivity.~~ x and y are the~~ The two-dimensional spatial coordinates are x and y.

[0017] ~~[0020]~~ The cross section of the strand skin is divided into small rectangles~~ of size~~ Δx by Δy, and the temperature is calculated in small time steps Δt. The starting point used for the temperature distribution is based on the assumption that the temperature on entry into the mould (in all rectangles) is the same as the tundish temperature of the steel.

[0018] ~~[0021]~~ The heat flux Q which is to be dissipated at the surface of the strand is calculated from the surface temperature T_o of the strand, the ambient temperature T_u, the surface area A and the heat transfer coefficient α, where $Q = \alpha (T_u - T_o) A$.

~~[0022] For cooling in the mould,~~ For cooling in the mould, ~~α is assumed to be constant and t_u is deemed to be equal to the temperature of the cooling water in the mould. For cooling by the cooling devices 5, T_U is assumed to be the same as the~~

~~temperature of the coolant and~~ is assumed to be constant and t_U is deemed to be equal to the temperature of the cooling water in the mould. For cooling by the cooling devices 5, T_U is assumed to be the same as the temperature of the coolant and α ~~is calculated, for example, as~~ is calculated, for example, as:

$$\alpha = \left(200 + 1.82V \cdot \frac{m^2\, min}{1}\right) \frac{w}{m^2 K} \qquad (3)$$

where V is the coolant volume in $\frac{l}{m^2\, min}$. V can be given differently for any point on the strand surface, with the result that the model can also be used to describe nozzle characteristics.

[0019] ~~[0023]~~ The model also calculates the profile of the solidification boundary from the profile of the temperature distribution in the strand.

[0020] ~~[0024]~~ The individual modeling parameters (variables) include:

- Mould length
- Strand geometry (height and width)
- Strand velocity
- Heat transfer coefficient α in the mould
- Coolant temperature in the mould
- Melt temperature
- Enthalpy of solidification
- Thermal conduction coefficient λ
- Specific heat capacity c
- Density ρ
- Length of each cooling zone

- Coolant volume V in each cooling zone
- Strand material

[0021] ~~[0025]~~ The temperature and material dependency of λ, c, enthalpy and ρ is taken into account in the model.

[0022] ~~[0026]~~ ~~FIG.~~FIGURE 3 shows a flow diagram for the iterative determination of an adaptation coefficient d_o for adapting the heat transfer coefficient α by means of a temperature and solidification model 13, the adapted heat transfer coefficient α_a being determined from the heat transfer coefficient α by

$$\alpha_a = d_o * \alpha.$$

[0023] ~~[0027]~~ For this purpose~~, in the temperature and solidification model 13~~ the solidification boundaries e_i in the strand are determined from given cooling of the strand by means of the temperature and solidification model 13. In a comparison unit 17, this solidification boundary e_i is compared with the roll strokes $\Delta W_{j,y,u}$ (lower) and $\Delta W_{j,y,o}$ (upper), which occur in the reduction stands and the rolling forces $F_{j,u}$ (lower) and $F_{j,o}$ (upper) in the reduction stands. If the values of the roll strokes which are typical for a change in geometry are undershot and/or the values of the rolling forces which are typical for a change in geometry are exceeded, the function block 16 determines a new proposal for an improved adaptation factor d_i. As a result, the solidification boundary is shifted until the corresponding limit values are exceeded or undershot, respectively. The starting value used for the iteration is a value $d_o = 1$.

The end of the iteration is set by the function block 18 $d_o = d_i$. ~~Then, the~~ The heat transfer coefficient α in equation 3 is replaced by the adapted heat transfer coefficient α_a.

[0024] ~~[0028]~~ It is ~~particularly advantageous to provide~~preferred if a pilot control is provided for the cooling device, in which case the transmission dependency of known times of the changes of installation values, such as ~~for example~~ the casting rate and/or the strand material, takes place.

We Claim:

11. ~~1.~~ A method for producing a ~~strand (1) made from~~ metal ~~by means of~~strand using a continuous-casting installation which has at least one cooling device ~~(5)~~ for cooling the strand ~~(1)~~, the cooling device ~~(5)~~ being assigned at least one reduction stand ~~(9, 10, 11)~~ for reducing the thickness of the strand ~~(1)~~, the strand ~~(1)~~, which during the thickness reduction~~,~~ ~~having~~has a solidified skin ~~(21)~~ and a liquid core ~~(2)~~, ~~characterized in that~~said method comprising setting the cooling ~~is set,~~ by means of a temperature and solidification model ~~(13), in such a manner~~so that ~~the~~a solidification boundary ~~(22)~~ between the solidified skin ~~(21)~~ and the liquid core ~~(2)~~ when the strand ~~(1)~~ enters the reduction stand ~~(9, 10, 11)~~ corresponds to a predetermined set solidification boundary between the solidified skin ~~(21)~~ and the liquid core ~~(2)~~.

~~2.~~ The method ~~as claimed in claim 1, characterized in that~~according to claim 11, further comprising using the temperature and solidification model ~~(13) is used~~ to determine the solidification boundary ~~(22)~~ between the solidified skin ~~(21)~~ and the liquid core ~~(2)~~ as a function of the cooling of the strand ~~(1)~~, ~~in particular in real time~~ and ~~continuously, and in that~~determining the required cooling of the strand ~~(1) is determined~~ iteratively as a function of the predetermined set solidification boundary ~~(e_0) between the solidified skin (21) and the liquid core (2)~~, iteration being repeated until ~~the~~any deviation in the solidification boundary ~~(e_i) between the solidified skin (21) and the liquid core~~

~~(2), which has been determined using the temperature and solidification model (13),~~ from the predetermined set solidification boundary ~~(e_i) between the solidified skin (21) and the liquid core (2) is less than a predetermined tolerance value.~~ is less than a predetermined tolerance value.

12. ~~3.~~ The method ~~as claimed in claim 1 or 2, characterized in that~~according to claim 11, further comprising using at least one ~~further~~ variable selected from the group of variables consisting of strand velocity, strand geometry, strand shell thickness, ~~mould~~mold length, time, strand material, coolant pressure or volume, droplet size of the coolant and coolant temperature ~~is used~~ to determine the ~~required~~ cooling of the strand ~~(1)~~ as a function of the predetermined set solidification boundary ~~between the solidified skin (21) and the liquid core (2)~~.

13. ~~4.~~ The method ~~as claimed in claim 1, 2 or 3, characterized in that~~according to claim 13, further comprising using the variables strand geometry, strand shell thickness, time, strand material, coolant pressure and volume, and coolant temperature ~~are also used~~ to determine the ~~required~~ cooling of the strand ~~(1)~~ as a function of the solidification boundary ~~(22) between the solidified skin (21) and the liquid core (2)~~.

14. ~~5.~~ The method ~~as claimed in claim 1, 2, 3 or 4 in which~~according to claim 11, further comprising arranging at least two reduction stands ~~(9, 10, 11) are arranged~~ downstream of the cooling device ~~(5)~~, ~~characterized in that~~and wherein the said at least two reduction stands ~~(9, 10, 11)~~ are assigned a set solidification boundary

between the solidified skin ~~(21)~~ and the liquid core ~~(2)~~ of the strand ~~(1)~~ when it enters ~~the~~a reduction stand ~~(9, 10, 11) in question~~.

15. ~~6.~~ The method ~~as claimed in claim 1, 2, 3, 4 or 5, characterized in that the action of the reduction in thickness produced by the reduction stand (9, 10, 11), in particular~~according to claim 11, further comprising taking into account the position of the solidification boundary ~~(22)~~ between solidified skin ~~(21)~~ and liquid core ~~(2), is also taken into account~~ in the temperature and solidification model ~~(13)~~.

16. ~~7.~~ The method ~~as claimed in~~according to claim ~~5, characterized in that the~~ 13, wherein modeling of the reduction in thickness produced by the reduction stand ~~(9, 10, 11)~~ is carried out using at least one of the variables reduction force and degree of reduction in thickness.

17. ~~8. The method as claimed in one of the preceding claims, characterized in that at least one of the variables reduction force and degree of reduction is measured in the reduction stand (9, 10, 11) and is used to adapt the temperature and solidification model (13).~~

18. ~~9. The method as claimed in claim 8, characterized in that~~The method according to claim 13, wherein at least one of the variables reduction force and degree of reduction is measured in the reduction stand ~~(9, 10, 11) are measured~~ and ~~are~~is used to adapt the temperature and solidification model ~~(13)~~.

19. ~~10.~~ A continuous-casting installation for producing a metal strand ~~(1)~~, ~~in particular using the method as claimed in one of the preceding claims, the continuous-casting installation having~~comprising at least one cooling device ~~(5)~~ for cooling the strand ~~(1)~~ and at least one associated reduction stand ~~(9, 10, 11)~~ for reducing the thickness of the strand ~~(1)~~, and a computing device for controlling the cooling of the strand by means of the cooling device ~~(5)~~, ~~characterized in that~~wherein a temperature and solidification model ~~(13)~~ for ~~such a~~ setting ~~of the~~a solidification boundary ~~(22)~~ between a solidified skin ~~(21)~~ and a liquid core ~~(2)~~ of the strand ~~(1)~~ when the strand ~~(1)~~ enters the reduction stand ~~(9, 10, 11)~~ is implemented ~~on~~in the computing device, and ~~in that~~ the solidification boundary ~~(22)~~ corresponds to a predetermined set solidification boundary between the solidified ~~skin (21) and the liquid core (2).~~skin and the liquid core.

ABSTRACT

A method and device for producing a strand of metal by means\ of a continuous-casting installation which has at least one cooling device for cooling the strand, the cooling device being assigned at least one reduction stand for reducing the thickness of the strand, the strand, during the thickness reduction, having a solidified skin and a liquid core. The cooling is set, by means of a temperature and solidification model, in such a manner that the solidification boundary between the solidified skin and the liquid core when the strand enters the reduction stand corresponds to a predetermined set solidification boundary between the solidified skin and the liquid core.

~~Fig. 1~~

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Description

Method and device for producing a strand made from metal

The invention relates to a method and a device for producing a strand of metal by means of a continuous-casting installation which has at least one cooling device for cooling the strand, the cooling device being assigned at least one reduction stand for reducing the thickness of the strand, the strand, during the thickness reduction, having a solidified skin and a liquid core.

To produce strands, it is known for a reduction stand to be assigned (downstream) to a continuous-casting installation. A particularly substantial reduction in thickness is achieved if the strand has a core which is still liquid when it enters the reduction stand. In this method, which is known as soft reduction, it is important for the liquid core to be large enough to ensure the required reduction in thickness of the strand while also not being so large that the strand breaks open and the liquid metal escapes. To achieve the required size of the liquid core on reaching the reduction stand, the strand is cooled by means of a cooling device, the cooling required being set by an operator after he has estimated the size of the liquid core.

It is an object of the invention to provide a method and a device for carrying out the method which allows soft reduction which is improved compared to the prior art, in particular even when the strand velocity varies.

According to the invention, the object is achieved by a method as described in claim 1 and a device as described in claim 10. To produce a strand made from metal by means of a continuous-casting installation which has at least one cooling device for cooling the strand, at least one reduction stand for reducing the thickness of the strand is arranged downstream of the cooling device, the strand, during the reduction in thickness, having a solidified skin and a liquid core, and the cooling being set, by means of a temperature and solidification model, in particular automatically, in such a manner that the solidification boundary between the solidified skin and the liquid core when the strand enters the reduction stand corresponds to a predetermined set solidification boundary between the solidified skin and the liquid core. In this way, particularly good soft reduction is achieved. Reduction stands in the context of the invention, may, in addition to simple rolling stands, be complex rolling stands, by means of which a defined geometry is imparted to the strand by rolling. The temperature and solidification model may, for example, be an analytical model, a neural network or a combination of an analytical model and a neural network.

The temperature and solidification model advantageously relates the cooling of the strand to the solidification boundary between the solidified skin and the liquid core. Such a configuration of the invention is particularly advantageous, since the temperature and solidification model simulates the solidification boundary between the solidified skin and the liquid core as a function of the amount of cooling using the cause-effect relationship between cooling and the solidification boundary between the solidified skin and the liquid core.

In an advantageous configuration of the invention, the temperature and solidification model is used to determine the solidification boundary between the solidified skin and the liquid core as a function of the cooling of the strand, in particular in real

time and continuously, and the required cooling of the strand is determined iteratively as a function of the predetermined set solidification boundary between the solidified skin and the liquid core, iteration being repeated until the deviation in the solidification boundary between the solidified skin and the liquid core, which has been determined using the temperature and solidification model, from the predetermined set solidification boundary between the solidified skin and the liquid core is less than a predetermined tolerance value.

In a further advantageous configuration of the invention, at least one further variable selected from the variables strand velocity, strand geometry, strand shell thickness, mould length, time, strand material, coolant pressure or volume, droplet size of the coolant and coolant temperature is used to determine the required cooling of the strand as a function of the predetermined set solidification boundary between the solidified skin and the liquid core.

In a further advantageous configuration of the invention, the variables strand geometry, strand shell thickness, time, strand material, coolant pressure or volume and coolant temperature are also used to determine the required cooling of the strand as a function of the solidification boundary between the solidified skin and the liquid core. The use of these variables is particularly suitable for achieving a particularly precise cooling of the strand.

In a further advantageous configuration of the invention, each reduction device is assigned a set solidification

boundary between the solidified skin and the liquid core of the strand.

In a further advantageous configuration of the invention, the action of the reduction in thickness produced by the reduction stand, in particular the position

of the solidification boundary between solidified skin and liquid core, is also modeled in the temperature and solidification model.

In a further advantageous configuration of the invention, the modeling of the reduction in thickness produced by the reduction stand is carried out using at least one of the variables reduction force and degree of reduction.

In a further advantageous configuration of the invention, at least one of the variables reduction force and degree of reduction is measured in the reduction stand and is used to adapt the temperature and solidification model.

In a further advantageous configuration of the invention, the variables reduction force and degree of reduction are measured in the reduction stand and are used to adapt the temperature and solidification model.

Further advantages and inventive details will emerge from the following description of an exemplary embodiment, with reference to the drawings and in conjunction with the subclaims. In the drawing:

FIG. 1 shows a continuous-casting installation,

FIG. 2 shows a flow diagram for the iterative determination of desired cooling of the strand by means of a temperature and solidification model,

FIG. 3 shows a flow diagram for the iterative determination of an adaptation coefficient.

FIG. 1 shows a continuous-casting installation. Reference numeral 1 denotes the cast strand, which has a solidified

skin 21 inside a solidification boundary

22 and a liquid core 2. The strand is moved using drive and guide rolls 4 and is cooled as it passes through cooling devices 5, which are advantageously designed as water-spraying devices. For the sake of clarity,

not all the drive and guide rolls 4 and cooling devices 5 are provided with reference numerals. In known methods, the cooling devices 5 are divided into cooling segments. This division is not necessary in the novel and inventive method, but may also be included. Both the drive rolls 4 and the cooling devices 5 are connected in terms of data technology to a computing device. In the present exemplary embodiment, bugs are connected in terms of data technology to the same automation unit 7. The automation unit 7 optionally also has a terminal (not shown) and a keyboard (not shown). In addition, the automation unit 7 is connected to a higher-level computer system 8. The material required for continuous casting, in this case liquid steel, is supplied via a feed apparatus 20. The control variables for the cooling devices 5 are calculated by means of a temperature and solidification model, i.e. a thermal model of the strand, which in the exemplary configuration is implemented on the higher-level computer system 8.

Reference numerals 9, 10 and 11 denote reduction stands assigned to the cooling device 5. In an advantageous configuration of the invention, these stands are connected in terms of data technology to the programmable-memory control unit 7, the rolling force and the degree of reduction, for example in the form of the roll nip, being transmitted to the automation unit 7. In the present exemplary embodiment, three reduction stands 9, 10 and 11 are provided. In the exemplary embodiment illustrated in FIG. 1, only a so-called soft reduction is carried out in the reduction stands 9 and 10. In soft reduction, the strand which is to be reduced is not fully solidified, but rather has a liquid core 2 and a solidified skin 21 when it enters a reduction stand. In

the exemplary embodiment shown in FIG. 1, only soft reduction for the strand 1 is

provided in the reduction stands 9 and 10. The cooling using the cooling devices 5 is set by means of the automation unit 7 in such a manner

that the solidification boundary 22 between the solidified skin 21 and the liquid core 2 of the strand 1 when it enters the reduction stands 9 and 10 corresponds to a desired set solidification boundary between the liquid core 2 and the solidified skin 21.

It is particularly advantageous for the reduction stand 9 to be arranged inside the cooling section, i.e. cooling devices 5 are provided upstream and downstream of the reduction stand 9. Furthermore, it is advantageously also possible for cooling devices to be provided downstream of the second reduction stand 10. The cooling device 9 is advantageously not arranged over the bending of the strand 1, as indicated for the sake of clarity in FIG. 1, but rather is arranged upstream of the bending of the strand or downstream of the bending of the strand 1.

FIG. 2 shows a flow diagram for the iterative determination of a set value k_0 for the cooling of the strand by means of a temperature and solidification model 13, the temperature and solidification model 13 and the remaining iterative sequences illustrated being implemented on the higher-level computer system 8. For this purpose, in the temperature and solidification model 13 the solidification boundaries e_i in the strand are determined from given cooling of the strand k_i by means of the temperature and solidification model 13. In a comparison unit 14, this solidification boundary e_i is compared with the set solidification boundary e_o in the strand. The comparison unit 14 interrogates whether $|e_i - e_o| \leq \Delta e_{max}$, where Δe_{max} is a predetermined tolerance value. If the difference between e_i and e_o is too high, the function block 12 determines a new proposal k_i for improved cooling of the strand. A value for the cooling

which has proven to be a suitable empirical value on average over a prolonged period is

used as the starting value for the iteration. If the difference between e_i and e_o is less than or equal to the tolerance value Δe_{max}, a set cooling fixing 15 is used to set the set value k_o for the cooling

of the strand to be equal to the value k_i. The values e_i, e_o, Δe_{max}, k_i, k_o are not necessarily scalars, but rather column matrices with one or more values. For example, the column matrix k_o contains the various control and command variables for the cooling devices 5 of the individual cooling segments 6 of a strand-cooling installation, or the column matrix e_o contains the set solidification boundaries at various locations of the strand. In an advantageous configuration, the iteration cycle illustrated in FIG 2 takes place on the basis of genetic algorithms. This is recommended in particular if k_i and k_o are column matrices containing numerous elements.

The temperature and solidification model 13 can be implemented both as a one-dimensional model and as a two-dimensional model. The heat conduction equation

$$\frac{\partial T}{\partial t} = a\left(\frac{\partial^2 T}{\partial^2} + \frac{\partial^2 T}{\partial y^2}\right) \qquad (1)$$

which for the temperature and solidification model 13 is used in difference form, i.e. in the form

$$\Delta_t T - a\Delta T\left(\frac{1}{\Delta x^2}\Delta_x^2 T + \frac{1}{\Delta y^2}\Delta_y^2 T\right) \qquad (2)$$

forms the basis for the temperature and solidification model, in this case shown for the two-dimensional case. In these equations, T is the temperature, t is the time and a is the thermal conductivity. x and y are the two-dimensional spatial coordinates.

The cross section of the strand skin is divided into small rectangles of size Δx by Δy, and the temperature

is calculated in small time steps Δt. The starting point used for the temperature distribution is based on the assumption that the temperature on entry into the mould (in all rectangles) is the same as the tundish temperature of the steel.

The heat flux Q which is to be dissipated at the surface of the strand is calculated from the surface temperature T_o of the strand, the ambient temperature T_u, the surface area A and the heat transfer coefficient α, where $Q = \alpha (T_u - T_o) A$.

For cooling in the mould, α is assumed to be constant and t_u is deemed to be equal to the temperature of the cooling water in the mould. For cooling by the cooling devices 5, T_U is assumed to be the same as the temperature of the coolant and α is calculated, for example, as

$$\alpha = \left(200 + 1.82V \frac{m^2 \min}{1}\right) \frac{w}{m^2 K} \qquad (3)$$

where V is the coolant volume in $\frac{l}{m^2\,min}$. V can be given differently for any point on the strand surface, with the result that the model can also be used to describe nozzle characteristics.

The model also calculates the profile of the solidification boundary from the profile of the temperature distribution in the strand.

The individual modeling parameters include:

- Mould length
- Strand geometry (height and width)
- Strand velocity
- Heat transfer coefficient α in the mould
- Coolant temperature in the mould
- Melt temperature

- Enthalpy of solidification

- Thermal conduction coefficient λ
- Specific heat capacity c
- Density ρ
- Length of each cooling zone
- Coolant volume V in each cooling zone
- Strand material

The temperature and material dependency of λ, c, enthalpy and ρ is taken into account in the model.

FIG. 3 shows a flow diagram for the iterative determination of an adaptation coefficient d_o for adapting the heat transfer coefficient α by means of a temperature and solidification model 13, the adapted heat transfer coefficient α_a being determined from the heat transfer coefficient α by

$$\alpha_a = d_o * \alpha.$$

For this purpose, in the temperature and solidification model 13 the solidification boundaries e_i in the strand are determined from given cooling of the strand by means of the temperature and solidification model 13. In a comparison unit 17, this solidification boundary e_i is compared with the roll strokes $\Delta W_{j,y,u}$ (lower) and $\Delta W_{j,y,o}$ (upper) which occur in the reduction stands and the rolling forces $F_{j,u}$ (lower) and $F_{j,o}$ (upper) in the reduction stands. If the values of the roll strokes which are typical for a change in geometry are undershot and/or the values of the rolling forces which are typical for a change in geometry are exceeded, the function block 16 determines a new proposal for an improved adaptation factor d_i. As a result, the solidification boundary is shifted until the corresponding limit values are exceeded or undershot, respectively. The starting value used for the iteration is a value $d_o = 1$. The end of the iteration

is set by the function block 18 $d_o = d_i$. Then, the heat

transfer coefficient α in equation 3 is replaced by the adapted heat transfer coefficient α_a.

It is particularly advantageous to provide a pilot control for the cooling device, in which case the transmission dependency of known times of the changes of installation values, such as for example the casting rate and/or the strand material, takes place.

Patent Claims

1. A method for producing a strand (1) made from metal by means of a continuous-casting installation which has at least one cooling device (5) for cooling the strand (1), the cooling device (5) being assigned at least one reduction stand (9, 10, 11) for reducing the thickness of the strand (1), the strand (1), during the thickness reduction, having a solidified skin (21) and a liquid core (2), characterized in that the cooling is set, by means of a temperature and solidification model (13), in such a manner that the solidification boundary (22) between the solidified skin (21) and the liquid core (2) when the strand (1) enters the reduction stand (9, 10, 11) corresponds to a predetermined set solidification boundary between the solidified skin (21) and the liquid core (2).

2. The method as claimed in claim 1, characterized in that the temperature and solidification model (13) is used to determine the solidification boundary (22) between the solidified skin (21) and the liquid core (2) as a function of the cooling of the strand (1), in particular in real time and continuously, and in that the required cooling of the strand (1) is determined iteratively as a function of the predetermined set solidification boundary (e_0) between the solidified skin (21) and the liquid core (2), iteration being repeated until the deviation in the solidification boundary (e_i) between the solidified skin (21) and the liquid core (2), which has been determined using the temperature and solidification model (13), from the predetermined

set solidification boundary (e_i) between the solidified skin (21) and the

liquid core (2) is less than a predetermined tolerance value.

3. The method as claimed in claim 1 or 2, characterized

in that at least one further variable selected from the variables strand velocity, strand geometry, strand shell thickness, mould length, time, strand material, coolant pressure or volume, droplet size of the coolant and coolant temperature is used to determine the required cooling of the strand (1) as a function of the predetermined set solidification boundary between the solidified skin (21) and the liquid core (2).

4. The method as claimed in claim 1, 2 or 3, characterized in that the variables strand geometry, strand shell thickness, time, strand material, coolant pressure and volume and coolant temperature are also used to determine the required cooling of the strand (1) as a function of the solidification boundary (22) between the solidified skin (21) and the liquid core (2).

5. The method as claimed in claim 1, 2, 3 or 4 in which at least two reduction stands (9, 10, 11) are arranged downstream of the cooling device (5), characterized in that at least two reduction stands (9, 10, 11) are assigned a set solidification boundary between the solidified skin (21) and the liquid core (2) of the strand (1) when it enters the reduction stand (9, 10, 11) in question.

6. The method as claimed in claim 1, 2, 3, 4 or 5, characterized in that the action of the reduction in thickness produced by the reduction stand (9, 10, 11), in particular the position of the solidification boundary (22) between solidified skin (21) and liquid core (2), is also taken into account in the temperature and solidification model (13).

7. The method as claimed in claim 5, characterized

in that the modeling of the reduction in thickness produced by the reduction stand (9, 10, 11) is carried out using at least one of the variables reduction force and degree of reduction in thickness.

8. The method as claimed in one of the preceding claims, characterized in that at least one of the variables reduction force and degree of reduction is measured in the reduction stand (9, 10, 11) and is used to adapt the temperature and solidification model (13).

9. The method as claimed in claim 8, characterized in that the variables reduction force and degree of reduction in the reduction stand (9, 10, 11) are measured and are used to adapt the temperature and solidification model (13).

10. A continuous-casting installation for producing a strand (1), in particular using the method as claimed in one of the preceding claims, the continuous-casting installation having at least one cooling device (5) for cooling the strand (1) and at least one associated reduction stand (9, 10, 11) for reducing the thickness of the strand (1), and a computing device for controlling the cooling of the strand by means of the cooling device (5), characterized in that a temperature and solidification model (13) for such a setting of the solidification boundary (22) between a solidified skin (21) and a liquid core (2) of the strand (1) when the strand (1) enters the reduction stand (9, 10, 11) is implemented on the computing device, and

in that the solidification boundary (22) corresponds to a predetermined set solidification boundary between the solidified

skin (21) and the liquid core (2).

GR 99 P 3439

Abstract

Method and device for producing a strand made of metal

A method and device for producing a strand of metal by means\ of a continuous-casting installation which has at least one cooling device for cooling the strand, the cooling device being assigned at least one reduction stand for reducing the thickness of the strand, the strand, during the thickness reduction, having a solidified skin and a liquid core. The cooling is set, by means of a temperature and solidification model, in such a manner that the solidification boundary between the solidified skin and the liquid core when the strand enters the reduction stand corresponds to a predetermined set solidification boundary between the solidified skin and the liquid core.

Fig. 1

Description

Method and device for producing a strand made from metal

The invention relates to a method and a device for producing a strand of metal by means of a continuous-casting installation which has at least one cooling device for cooling the strand, the cooling device being assigned at least one reduction stand for reducing the thickness of the strand, the strand, during the thickness reduction, having a solidified skin and a liquid core.

To produce strands, it is known for a reduction stand to be assigned (downstream) to a continuous-casting installation. A particularly substantial reduction in thickness is achieved if the strand has a core which is still liquid when it enters the reduction stand. In this method, which is known as soft reduction, it is important for the liquid core to be large enough to ensure the required reduction in thickness of the strand while also not being so large that the strand breaks open and the liquid metal escapes. To achieve the required size of the liquid core on reaching the reduction stand, the strand is cooled by means of a cooling device, the cooling required being set by an operator after he has estimated the size of the liquid core.

The document "Neubau einer Vertikalstranggießanlage bei der AG der Dillinger Hüttenwerke"; [Construction of a new vertical continuous-casting installation at Dillinger Hüttenwerke AG]" Stahl and Eisen 117, No. 11; 10 November 1997, demonstrates the problems of the location and positioning of the blunt tip of a strand in relation to the soft reduction zone, and it is

taught that the soft reduction zone should be tracked beyond the respective position of the blunt tip during casting. This is possible through the fact that the segments can be hydraulically positioned in the strand-guiding section.

It is an object of the invention to provide a method and a device for carrying out the method which allows soft reduction which is improved compared to the prior art, in particular even when the strand velocity varies.

99 P 3439

10030340.082702

10/030340

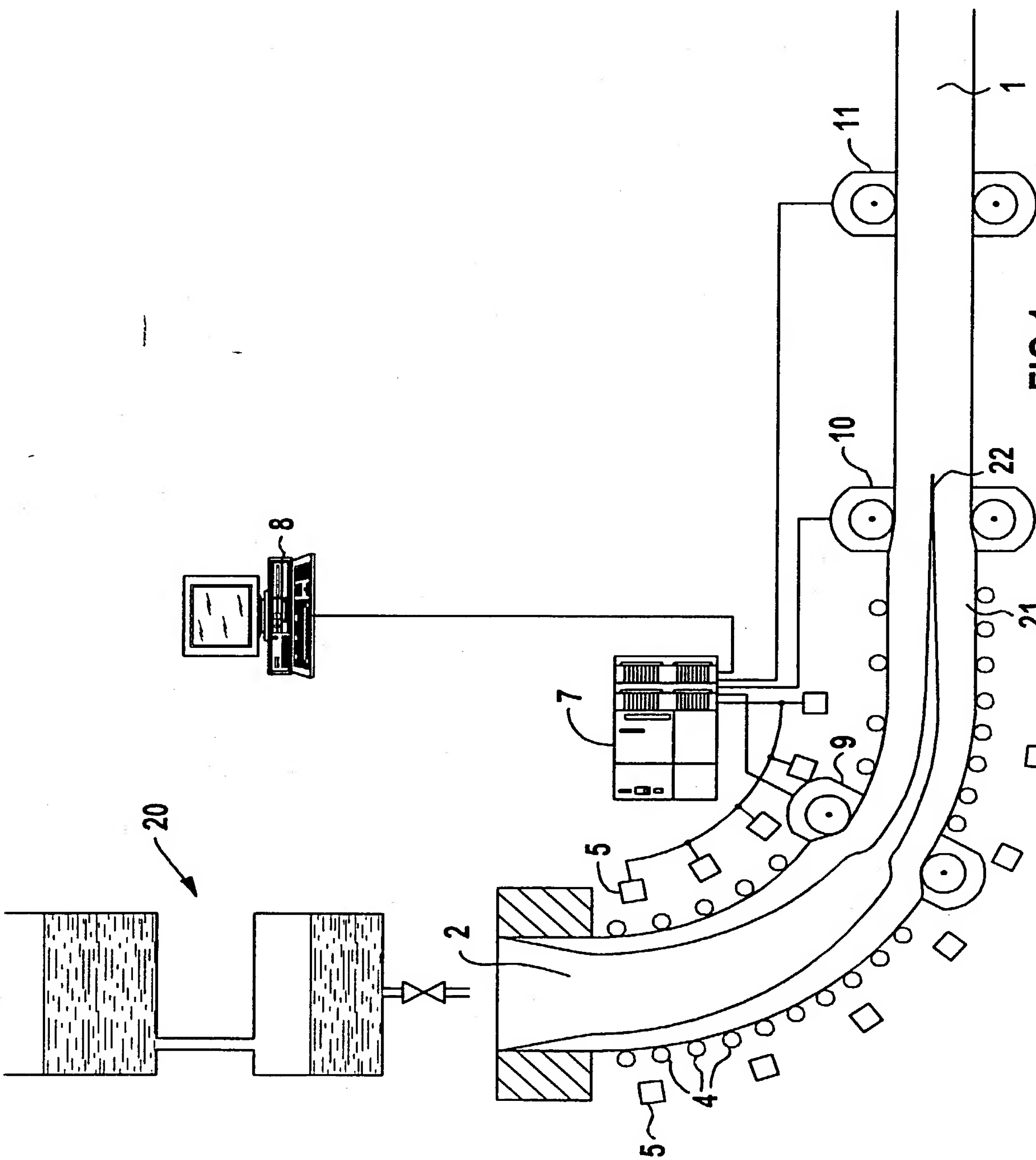
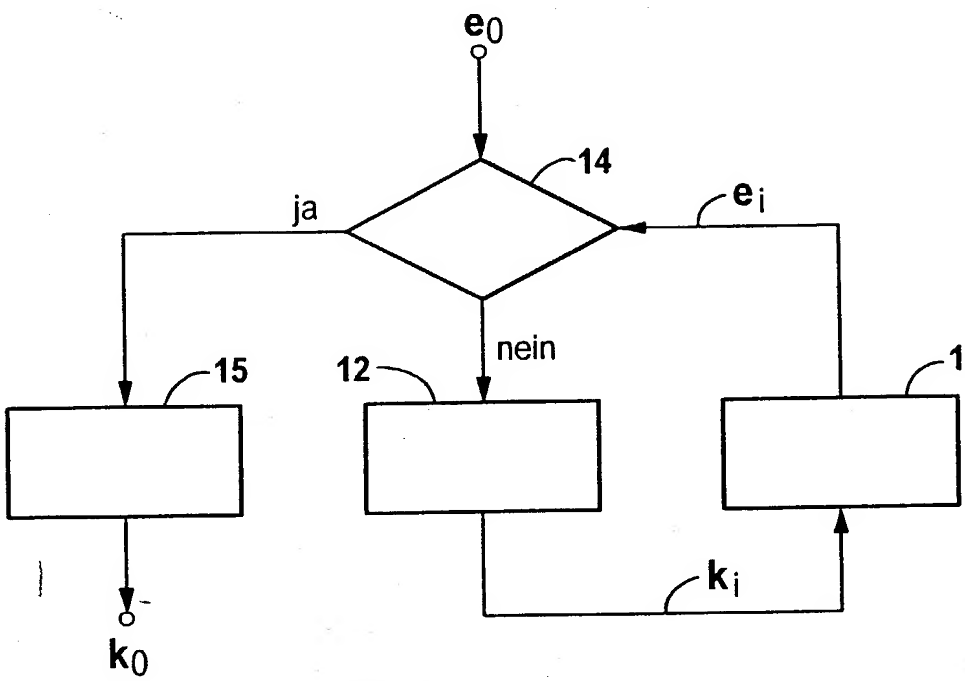


FIG 1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ja
e_i
nein
15
12
13
k_i
k_0

FIG 2

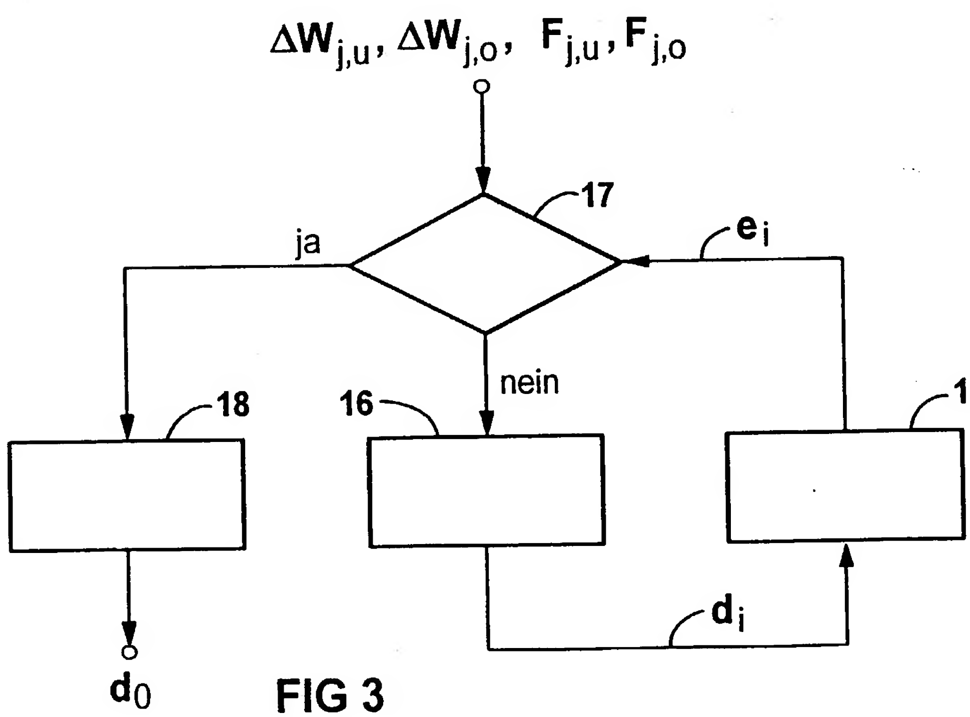
$\Delta W_{j,u}, \Delta W_{j,o}, F_{j,u}, F_{j,o}$
17
ja
e_i
nein
18
16
13
d_i
d_0

FIG 3

Declaration and Power of Attorney For Patent Application

Erklärung Für Patentanmeldungen Mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren und Einrichtung zum Herstellen eines Stranges aus Metall

Method and device for making a metal strand

deren Beschreibung

(zutreffendes ankreuzen)
☐ hier beigefügt ist.
☒ am 29. Juni 2000 als
PCT internationale Anmeldung
PCT Anmeldungsnummer PCT/DE00/02117
eingereicht wurde und am ______
abgeändert wurde (falls tatsächlich abgeändert).

the specification of which

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☐ is attached hereto.
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PCT Application No. ____ PCT/DE00/02117
and was amended on ________
(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign appplications
Priorität beansprucht

Priority Claimed

19931331.8	DE	07.07.1999	☒	☐
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein
			☐	☐
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein
			☐	☐
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozeßordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35. United States Code. §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occured between the filing date of the prior application and the national or PCT international filing date of this application.

PCT/DE00/02117	29. Juni 2000		pending
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D, M, Y) (Anmeldedatum T, M, J)	(Status) (patentiert, anhängig, aufgegeben)	(Status) (patented, pending, abandoned)
(Application Serial No.) (Anmeldeseriennummer)	(Filing Date D,M,Y) (Anmeldedatum T, M; J)	(Status) (patentiert, anhängig, aufgeben)	(Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

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POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. *(list name and registration number)*

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(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).

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Unterschrift des Erfinders Datum 21.12.01	Inventor's signature Date 21.12.01
Wohnsitz: BAIERSDORF, DEUTSCHLAND	Residence: BAIERSDORF, GERMANY DEX
Staatsangehörigkeit: DEUTSCH	Citizenship: GERMAN
Postanschrift: LUDWIG-THOMA-STR. 17	Post Office Address: LUDWIG-THOMA-STR. 17
91083 BAIERSDORF DEUTSCHLAND	91083 BAIERSDORF GERMANY

Voller Name des vierten Miterfinders:	Full name of fourth joint inventor:
HANS-HERBERT WELKER	HANS-HERBERT WELKER
Unterschrift des Erfinders Datum: Hans Herbert Welker 21.Dez 01	Inventor's signature Date: Hans Herbert Welker 21.Dez01
Wohnsitz: HERZOGENAURACH, DEUTSCHLAND	Residence: HERZOGENAURACH, GERMANY DEX
Staatsangehörigkeit: DEUTSCH	Citizenship: GERMAN
Postanschrift: LANGENZENNER STR 9	Post Office Address: LANGENZENNER STR 9
91074 HERZOGENAURACH DEUTSCHLAND	91074 HERZOGENAURACH GERMANY

Voller Name des fünften Miterfinders:	Full name of fifth joint inventor:
Unterschrift des Erfinders Datum	Inventor's signature Date
Wohnsitz ,	Residence ,
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

Voller Name des sechsten Miterfinders:	Full name of sixth joint inventor:
Unterschrift des Erfinders Datum	Inventor's signature Date
Wohnsitz ,	Residence ,
Staatsangehörigkeit	Citizenship
Postanschrift	Post Office Address

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